La mécanique du toucher sensations localisés

Vincent Hayward







with vision,
$$p(l,v,\lambda,t)$$
 is in \mathbb{R}^7

Adelson E. H., Bergen J. R. '81. The 'plenoptic' function and the elements of early vision with touch



Hayward, V. 2011. Is There a 'Plenhaptic' Function? *Philosophical Transactions of the Royal Society B*, 366:3115–3122





haptic probes





Hayward, V. 2008. A Brief Taxonomy of Tactile Illusions and Demonstrations That Can Be Done In a Hardware Store. Brain Research Bulletin, 75:742-752.





Levesque, V., Hayward, V. 2003. Experimental Evidence of Lateral Skin Strain During Tactile Exploration. Proc. *Eurohaptics 2003*. pp. 261–275





Robles De La Torre, G., Hayward, V. 2001. Force Can Overcome Object Geometry In The Perception Of Shape Through Active Touch. *Nature*, 412:445-448





Dostmohamed, H., Hayward. V., 2005. Trajectory of Contact Region On the Fingerpad Gives the Illusion of Haptic Shape. *Experimental Brain Research*. 164:387-394.





Konkle, T., Wang, Q., Hayward, V., Moore, C. I. 2009. Motion aftereffects transfer between touch and vision. *Current Biology*, 19(9):745-750.





B. Touch to Vision







Gueorguiev, D., Bochereau, S., Mouraux, A., Hayward, V. and Thonnard, J-L. 2016. Touch uses frictional cues to discriminate flat materials. *Scientific Reports*, 6 :25553.





0.0 second





0.5 second





1.0 second





2.0 second





10 second





60 second

Dzidek, B., Bochereau, S., Johnson, S., Hayward, V., and Adams, M. 2017. Why pens have rubbery grips. *PNAS*, 114:10864–10869. (See also Sticky Fingers, *Nature Physics*, News and Views, Nov 2017 and Get a Grip (*Nature Materials*, News and Views, Nov 2017)













Dupin, L., Hayward, V. Wexler, M. 2015. Direct Coupling of Haptic Signals Between Hands. *PNAS*, 112(2):619-624.





Shao, Y., Hayward, V., Visell, Y. 2016. Spatial Patterns of Cutaneous Vibration During Whole-Hand Haptic Interactions. *PNAS*, 113(15):4188–4193







Spatiotemporal patterns of cutaneous vibration





Work in progress with Shao and Visell: efficient encoding hypothesis

Each estimated tactile stimulus:

$$\hat{v}(x,t) = \sum_{i=1}^{M} \sum_{\tau=0}^{T-1} h_i(t-\tau) w_i(x,\tau),$$

where,

$$w_i(x,t) \ge 0, \ h_i(t) \ge 0..$$











































Miller, L. E., Montroni, L., Koun, E., Salemme, R., Hayward, V., Farné, A. (2018). Sensing with tools extends somatosensory processing beyond the body. *Nature*, 561(7722):239-242.

















- The cuneate nucleus receives 40,000 primary afferents
- About 80,000 neurons in the nucleus
- About 100 afferents converge to one single input cell
- A single afferent makes pprox 100 synaptic contacts per neuron
- Less than 10 synapses per neuron have high weights
- What does it do?

Bengtsson, F., Brasselet, R., Johansson, R. S., Arleo, A., Jörntell, H. 2013. Integration of Sensory Quanta in Cuneate Nucleus Neurons In Vivo. *PLOS One*, 8(2):e56630









Johansson, R. S., Landström, U., and Lundström, R. (1982) Responses of Mechanoreceptive Afferent Units in the Glabrous Skin of the Human Hand to Sinusoidal Skin Displacements. *Brain Research*, 244:17–25













Hayward, V., Terekhov, A. V., Wong, S.-C., Geborek, P, Bengtsson, F., Jörntell, H. 2014. Spatio-Temporal Skin Strain Distributions Evoke Low Variability Spike Responses In Cuneate Neurons. *Journal of the Royal Society* Interface, 11:20131015









SORBONNE 37



Jörntell, H., Bengtsson, F., Geborek, P., Spanne, A., Terekhov, A., Hayward, V. 2014. Segregation of tactile input features in neurons of the cuneate nucleus. *Neuron*, 83:1444–1452.













